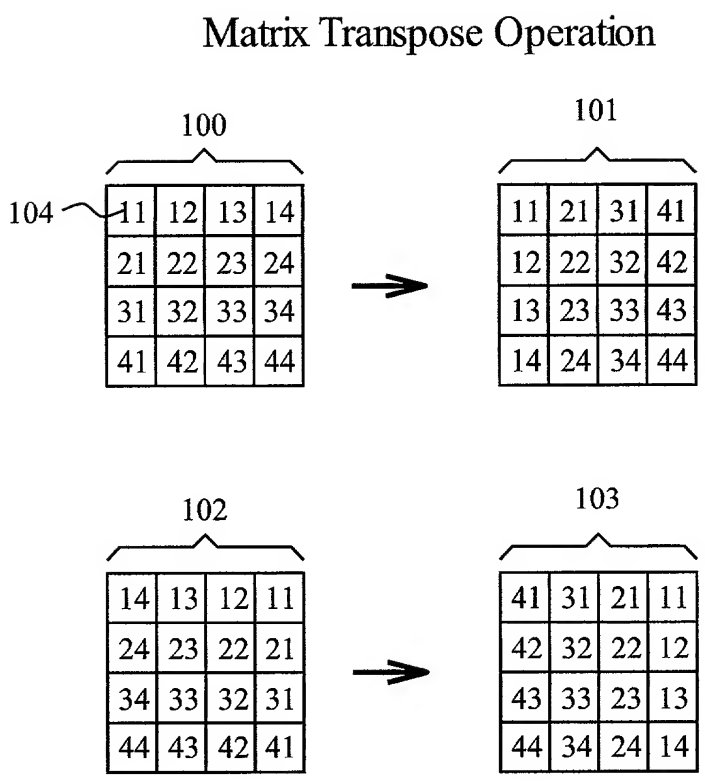
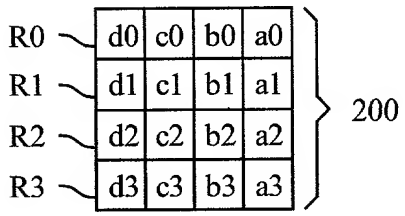

Matrix Transpose Operation
100
101
104
11 12 13 14
21 22 23 24
31 32 33 34
41 42 43 44
11 21 31 41
12 22 32 42
13 23 33 43
14 24 34 44
102
103
14 13 12 11
24 23 22 21
34 33 32 31
44 43 42 41
41 31 21 11
42 32 22 12
43 33 23 13
44 34 24 14

Figure 1

Method for matrix transpose (prior art)



t0 = Unpack LW R0 R1 = | b1 | b0 | a1 | a0 |

t1 = Unpack LW R2 R3 = | b3 | b2 | a3 | a2 |

t2 = Unpack HW R0 R1 = | d1 | d0 | c1 | c0 |

t3 = Unpack HW R2 R3 = | d3 | d2 | c3 | c2 |

V0 = Unpack LD t0 t1 = | a3 | a2 | a1 | a0 |

V1 = Unpack HD t0 t1 = | b3 | b2 | b1 | b0 |

V2 = Unpack LD t2 t3 = | c3 | c2 | c1 | c0 |

V3 = Unpack HD t2 t3 = | d3 | d2 | d1 | d0 |

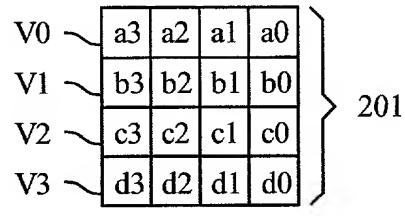
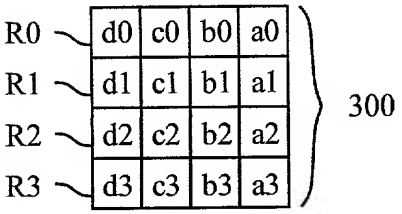


Figure 2

Method for Matrix Transpose (prior art)



t0 = Unpack LW R0 R2 = | b2 | b0 | a2 | a0 |

t1 = Unpack LW R1 R3 = | b3 | b1 | a3 | a1 |

t2 = Unpack HW R0 R2 = | d2 | d0 | c2 | c0 |

t3 = Unpack HW R1 R3 = | d3 | d1 | c3 | c1 |

V0 = Unpack LW t0 t1 = | a3 | a2 | a1 | a0 |

V1 = Unpack HW t0 t1 = | b3 | b2 | b1 | b0 |

V2 = Unpack LW t2 t3 = | c3 | c2 | c1 | c0 |

V3 = Unpack HW t2 t3 = | d3 | d2 | d1 | d0 |

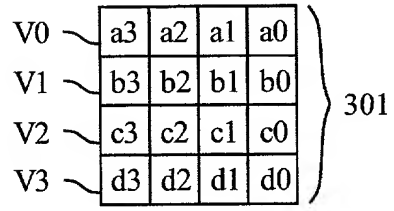


Figure 3

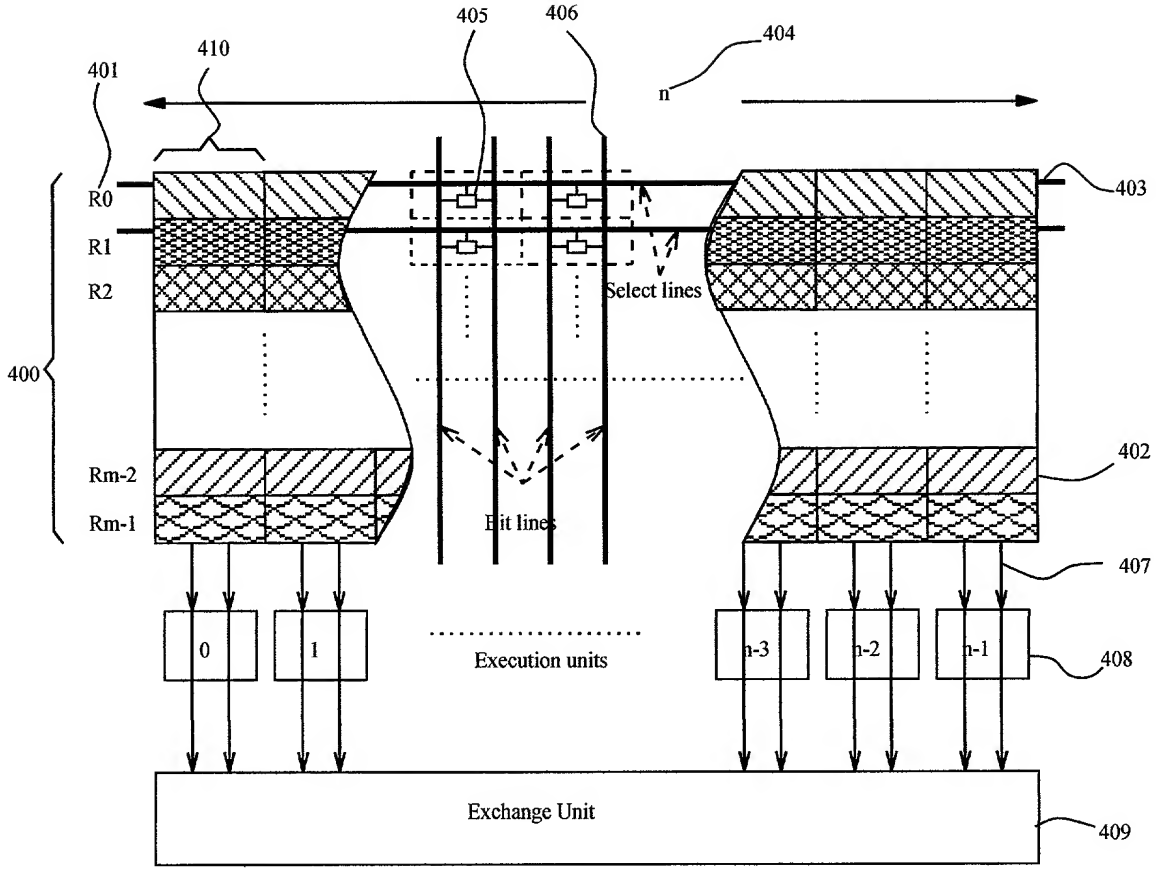

405
406
404
410
401
n
403
R0
R1
R2
Select lines
400
Rm-2
Rm-1
402
Bit lines
407
0
1
Execution units
n-3
n-2
n-1
408
Exchange Unit
409

Figure 4

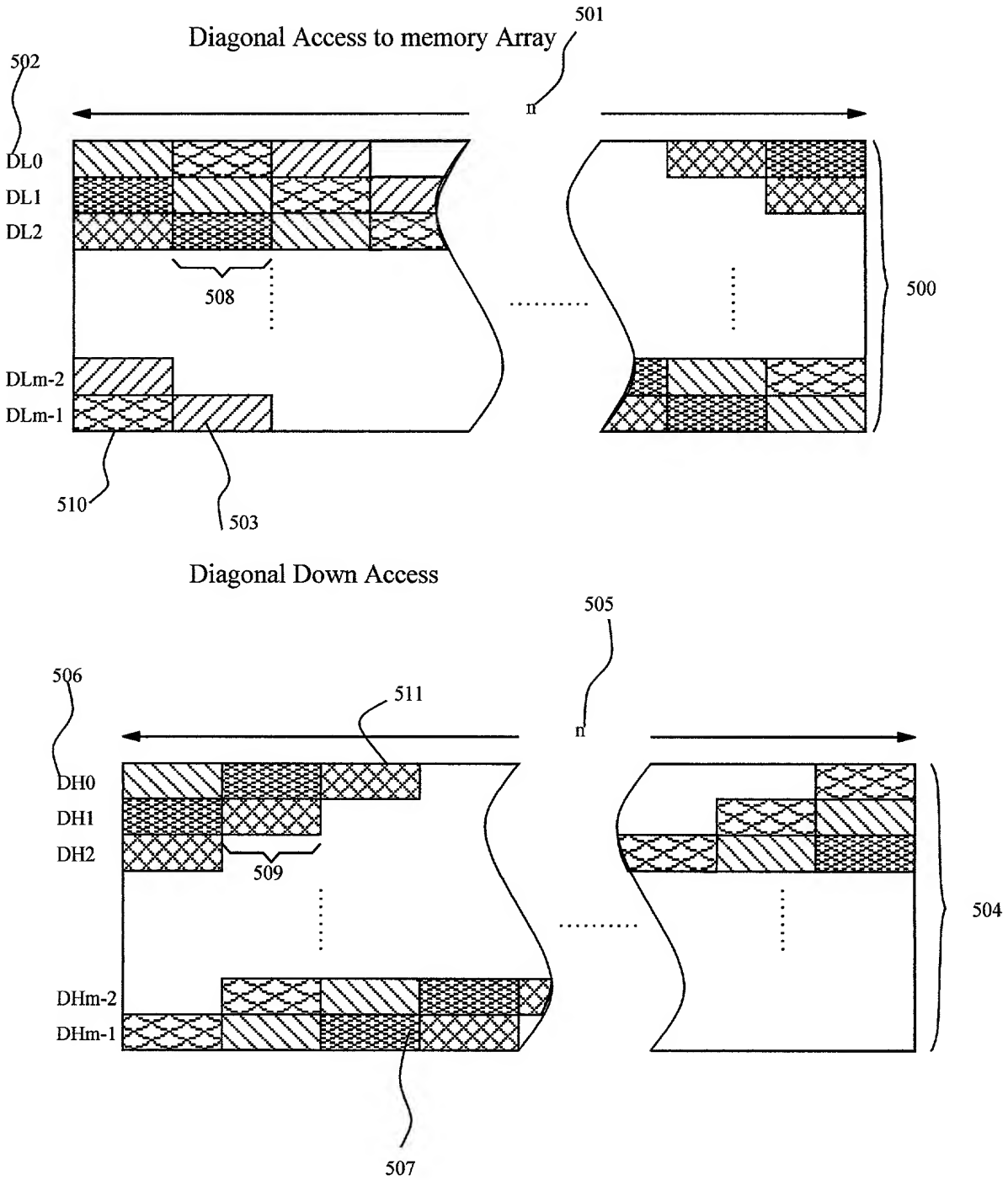

Diagonal Access to memory Array
501
502
n
DL0
DL1
DL2
508
500
DLm-2
DLm-1
510
503
Diagonal Down Access
505
506
511
n
DH0
DH1
DH2
509
504
DHm-2
DHm-1
507
Diagonal Up Access

Figure 5

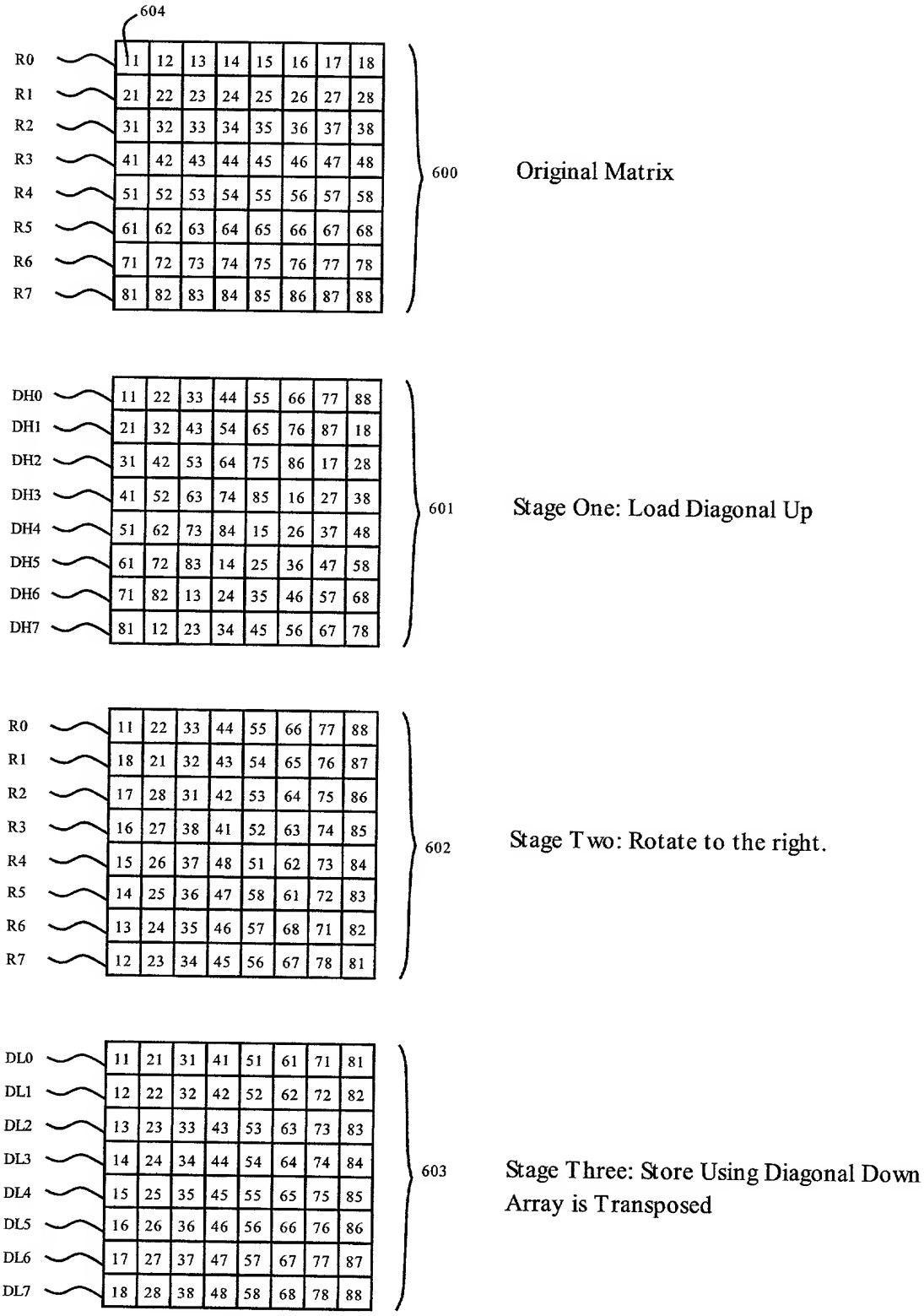

604
R0 11 12 13 14 15 16 17 18
R1 21 22 23 24 25 26 27 28
R2 31 32 33 34 35 36 37 38
R3 41 42 43 44 45 46 47 48
R4 51 52 53 54 55 56 57 58
R5 61 62 63 64 65 66 67 68
R6 71 72 73 74 75 76 77 78
R7 81 82 83 84 85 86 87 88
600
Original Matrix
DH0 11 22 33 44 55 66 77 88
DH1 21 32 43 54 65 76 87 18
DH2 31 42 53 64 75 86 17 28
DH3 41 52 63 74 85 16 27 38
DH4 51 62 73 84 15 26 37 48
DH5 61 72 83 14 25 36 47 58
DH6 71 82 13 24 35 46 57 68
DH7 81 12 23 34 45 56 67 78
601
Stage One: Load Diagonal Up
R0 11 22 33 44 55 66 77 88
R1 18 21 32 43 54 65 76 87
R2 17 28 31 42 53 64 75 86
R3 16 27 38 41 52 63 74 85
R4 15 26 37 48 51 62 73 84
R5 14 25 36 47 58 61 72 83
R6 13 24 35 46 57 68 71 82
R7 12 23 34 45 56 67 78 81
602
Stage Two: Rotate to the right.
DL0 11 21 31 41 51 61 71 81
DL1 12 22 32 42 52 62 72 82
DL2 13 23 33 43 53 63 73 83
DL3 14 24 34 44 54 64 74 84
DL4 15 25 35 45 55 65 75 85
DL5 16 26 36 46 56 66 76 86
DL6 17 27 37 47 57 67 77 87
DL7 18 28 38 48 58 68 78 88
603
Stage Three: Store Using Diagonal Down
Array is Transposed

Figure 6A

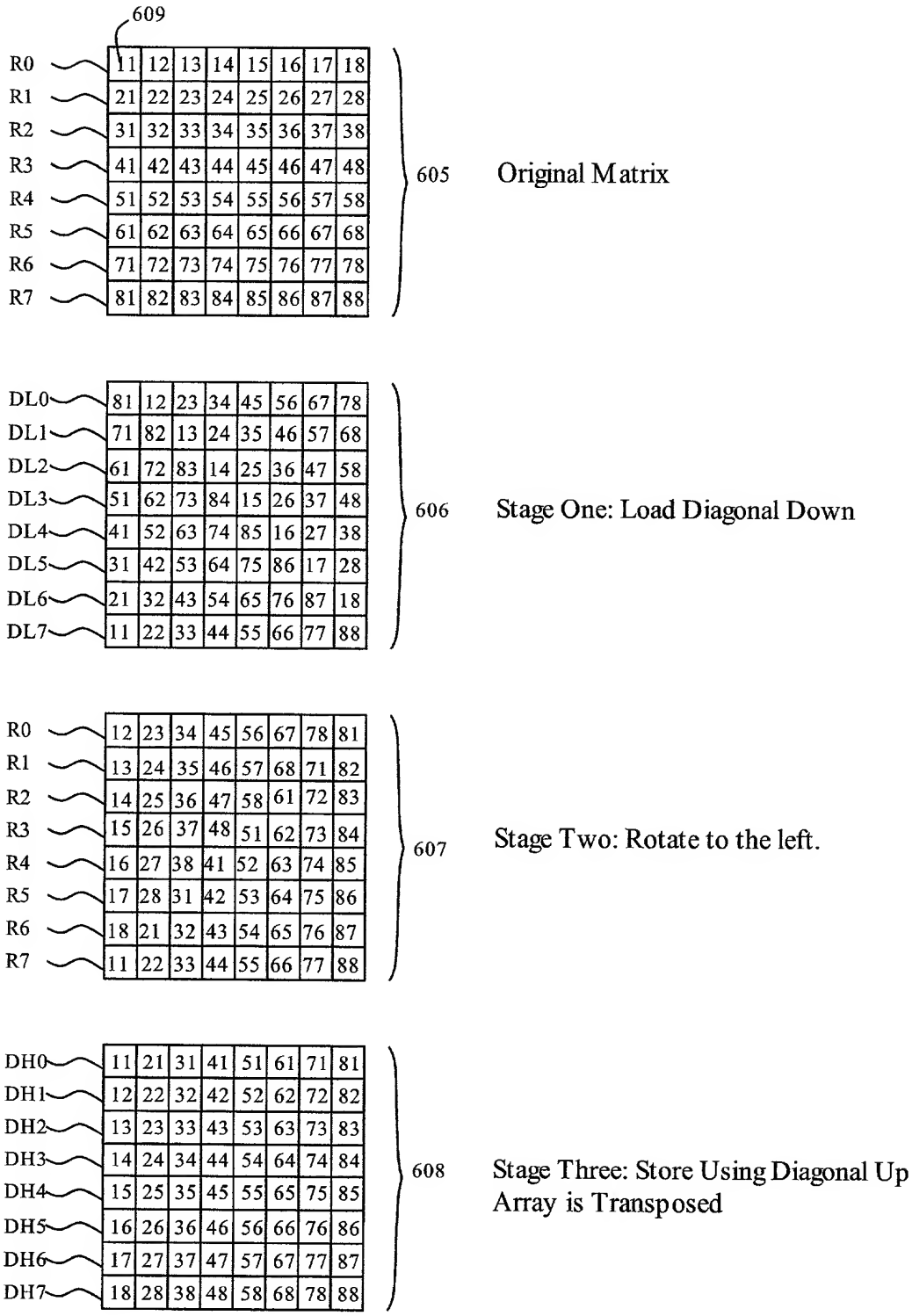

609
R0 11 12 13 14 15 16 17 18
R1 21 22 23 24 25 26 27 28
R2 31 32 33 34 35 36 37 38
R3 41 42 43 44 45 46 47 48
R4 51 52 53 54 55 56 57 58
R5 61 62 63 64 65 66 67 68
R6 71 72 73 74 75 76 77 78
R7 81 82 83 84 85 86 87 88
605
Original Matrix
DL0 81 12 23 34 45 56 67 78
DL1 71 82 13 24 35 46 57 68
DL2 61 72 83 14 25 36 47 58
DL3 51 62 73 84 15 26 37 48
DL4 41 52 63 74 85 16 27 38
DL5 31 42 53 64 75 86 17 28
DL6 21 32 43 54 65 76 87 18
DL7 11 22 33 44 55 66 77 88
606
Stage One: Load Diagonal Down
R0 12 23 34 45 56 67 78 81
R1 13 24 35 46 57 68 71 82
R2 14 25 36 47 58 61 72 83
R3 15 26 37 48 51 62 73 84
R4 16 27 38 41 52 63 74 85
R5 17 28 31 42 53 64 75 86
R6 18 21 32 43 54 65 76 87
R7 11 22 33 44 55 66 77 88
607
Stage Two: Rotate to the left.
DH0 11 21 31 41 51 61 71 81
DH1 12 22 32 42 52 62 72 82
DH2 13 23 33 43 53 63 73 83
DH3 14 24 34 44 54 64 74 84
DH4 15 25 35 45 55 65 75 85
DH5 16 26 36 46 56 66 76 86
DH6 17 27 37 47 57 67 77 87
DH7 18 28 38 48 58 68 78 88
608
Stage Three: Store Using Diagonal Up
Array is Transposed

Figure 6B

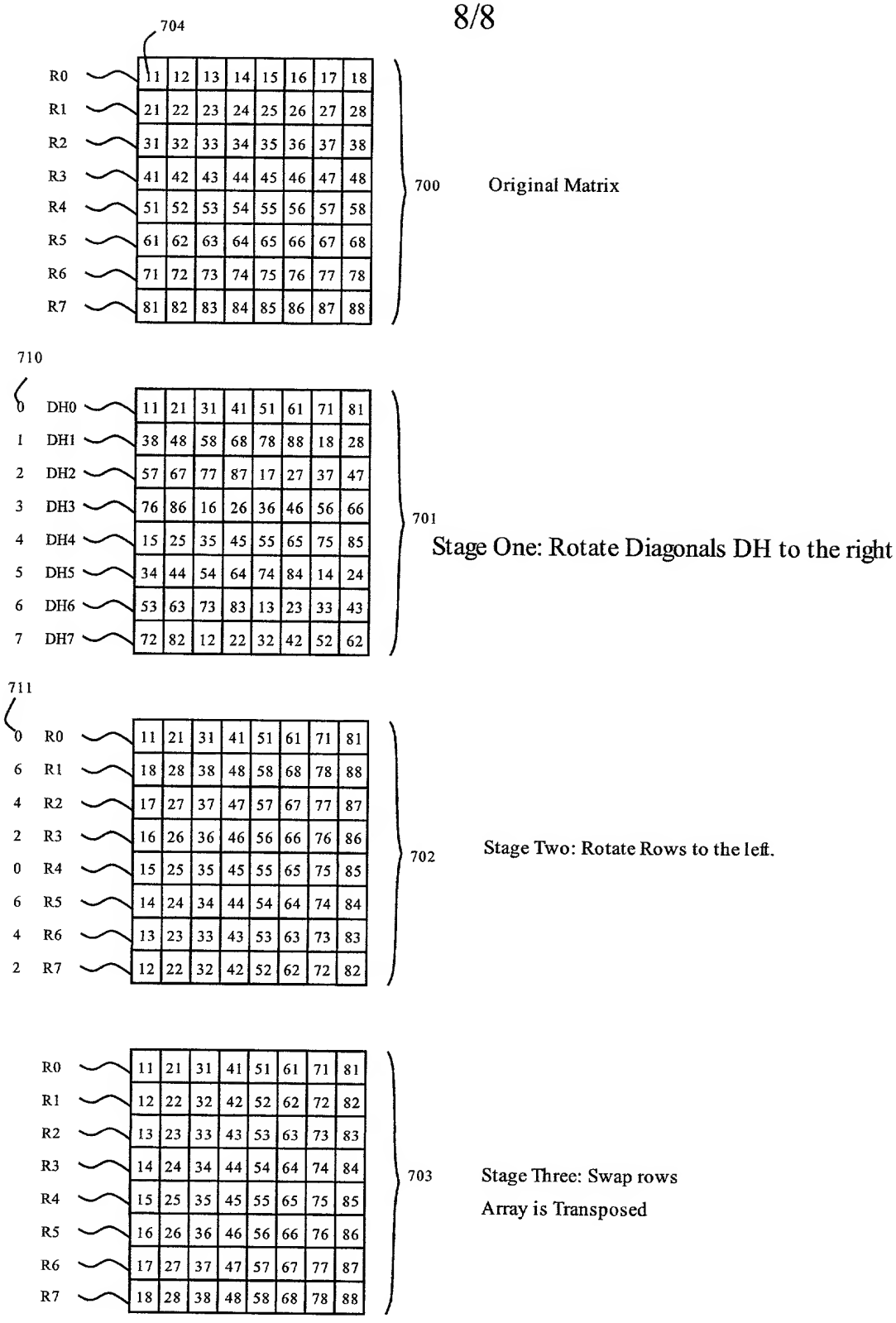

704
R0 11 12 13 14 15 16 17 18
R1 21 22 23 24 25 26 27 28
R2 31 32 33 34 35 36 37 38
R3 41 42 43 44 45 46 47 48
R4 51 52 53 54 55 56 57 58
R5 61 62 63 64 65 66 67 68
R6 71 72 73 74 75 76 77 78
R7 81 82 83 84 85 86 87 88
700
Original Matrix
710
0 DH0 11 21 31 41 51 61 71 81
1 DH1 38 48 58 68 78 88 18 28
2 DH2 57 67 77 87 17 27 37 47
3 DH3 76 86 16 26 36 46 56 66
4 DH4 15 25 35 45 55 65 75 85
5 DH5 34 44 54 64 74 84 14 24
6 DH6 53 63 73 83 13 23 33 43
7 DH7 72 82 12 22 32 42 52 62
701
Stage One: Rotate Diagonals DH to the right
711
0 R0 11 21 31 41 51 61 71 81
6 R1 18 28 38 48 58 68 78 88
4 R2 17 27 37 47 57 67 77 87
2 R3 16 26 36 46 56 66 76 86
0 R4 15 25 35 45 55 65 75 85
6 R5 14 24 34 44 54 64 74 84
4 R6 13 23 33 43 53 63 73 83
2 R7 12 22 32 42 52 62 72 82
702
Stage Two: Rotate Rows to the left.
R0 11 21 31 41 51 61 71 81
R1 12 22 32 42 52 62 72 82
R2 13 23 33 43 53 63 73 83
R3 14 24 34 44 54 64 74 84
R4 15 25 35 45 55 65 75 85
R5 16 26 36 46 56 66 76 86
R6 17 27 37 47 57 67 77 87
R7 18 28 38 48 58 68 78 88
703
Stage Three: Swap rows
Array is Transposed

Figure 7